4 prts

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Patent Application

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VALVE SEAT AND METHOD FOR PRODUCING A VALVE SEAT

BACKGROUND OF THE INVENTION

Field of the invention

[0002] The invention relates to a valve seat for a cylinder head of an internal combustion engine of the type defined in more detail in the preamble of claim 1. Furthermore, the invention relates to a process for producing a valve seat for a cylinder head of an internal combustion engine of the type defined in more detail in the preamble of claim 10.

Related Art of the Invention

[0003] DE 199 12 889 A1 describes a valve seat of the generic type and a process of the generic type for producing it. In this case, an additional material, namely an alloy or a mixture of an aluminum-silicon alloy and nickel, is fused to the base material of the cylinder head by a laser beam.

[0004] DE 35 17 077 C1 has disclosed a process for reinforcing the valve seat surface of a gas exchange valve in which reinforcing plating material preferably consisting of a nickel- or cobalt-based superalloy is introduced into an encircling recess on the valve plate.

[0005] A process for coating the surface of metallic workpieces with an additional material in powder or wire form is described by DE 199 12 894 A1.

[0006] A further process of this type is known from EP 0 092 683 B1. In this case, the base material of the cylinder head substantially comprises aluminum, and either iron or nickel or an alloy comprising one of these two metals is

used as the main constituent of the additional material for forming the valve seat.

[0007] One drawback in this case is that iron and nickel have a significantly higher melting point than the cylinder head, which consists of aluminum. This can lead to the cylinder head already being in molten form under the action of a laser beam when the additional material is only just starting to melt. Moreover, it may be the case that the previously liquid iron has already solidified while the aluminum is still in molten form. This leads to the formation of intermetallic phases in the interfacial region between iron and aluminum material, which can lead to a very brittle microstructure. Consequently, it is difficult to achieve a homogeneous join between the valve seat to be created and the base material of the cylinder head; the different surface tensions of the materials also play a major role in this context.

[0008] EP 0 228 282 B1 describes a cylinder head consisting of an aluminum alloy. The valve seats of this cylinder head are formed from a plated-on copper alloy layer.

[0009] If copper is used as material for valve seats, however, the drawback arises, in particular in the case of diesel internal combustion engines, that the sulfur contained in the diesel fuel attacks the copper, which causes problems with regard to the exhaust gases produced and corrosion. The use of copper for valve seats is therefore only appropriate for spark-ignition internal combustion engines, which means that this solution cannot be employed economically.

[00010] DE 196 39 480 A1 has described a process for the

internal coating of cylinder liners by means of pulverulent additional materials which are alloyed on by laser radiation.

[00011] DE 22 00 003 A1 reveals a process for the surface treatment of light metal components, in particular of light metal pistons of internal combustion engines, having an additional material which increases the strength and/or is resistant to wear.

[00012] Moreover, for further prior art relating to valve seats for internal combustion engines and processes for producing them, reference is made to the following documents: US 4,059,876, JP 05256190 A, JP 07284970 A, JP 08047787 A, JP 08224680 A, JP 08224681 A, JP 08224682 A, JP 08224683 A, JP 10141132 A, JP 10176511 A, JP 11002154 A, EP 0 209 366 A1, US 4,723,518, JP 02196117 A, JP 04123885 A, JP 06042320 A and JP 08174245 A.

[00013] If the valve seat is to be fused as additional material to the base material of the cylinder head, the problem tends to arise that this additional material has to ensure both bonding to the base material of the cylinder head and the strength properties for absorbing the forces introduced by the gas exchange valve as well as the tribological properties required to minimize the wear at the surface of the valve seat. This imposes very complex boundary conditions for the choice of materials, which is reflected in the prior art by the very wide range of proposals which have been made as to the use of certain materials. Hitherto, however, no solution has been so convincing that it has been able to replace the process of pressing the valve seat rings into place, which has long been used in practice.

SUMMARY OF THE INVENTION

[00014] Therefore, it is an object of the present invention to provide a valve seat for a cylinder head of an internal combustion engine and a process for producing it which has both good bonding to the base material of the cylinder head and good strength and wear properties.

[00015] According to the invention, this object is achieved by the features listed in claim 1.

[00016] The two layers above one another according to the invention advantageously allow the very different roles which the valve seat has to perform to be split. For example, according to the invention, the inner layer, facing the cylinder head, can perform the role of joining the valve seat to the base material of the cylinder head and the outer layer, remote from the cylinder head, can be designed in such a way that it has good strength and wear properties for the valve seat.

[00017] This advantageously improves the bonding of the valve seat to the cylinder head, which prevents the whole of the valve seat from becoming detached from the cylinder head. Nevertheless, relatively high loads can be imposed on the valve seat according to the invention with relatively low wear rates, on account of the configuration of the outer layer. The overall result achieved in this way is a considerably widened range of materials, in particular also with regard to the different demands imposed by spark-ignition and diesel internal combustion engines.

[00018] If, in an advantageous configuration of the invention,

the inner layer has good heat conduction properties, the dissipation of heat from the valve seat surface into the cylinder head is advantageously improved since the melt-metallurgy bonding avoids the air gap between the valve seat and the cylinder head.

[00019] In particular, in the case of cylinder heads made from aluminum, it has proven advantageous for the inner layer to include copper or a copper alloy, since in particular a material of this type can be successfully bonded to the aluminum material of the cylinder head. In this context, the outer layer prevents the copper material of the inner layer from combining with sulfur-containing fuel or exhaust-gas constituents, thereby having an adverse effect on the emission levels.

[00020] Furthermore, it is possible to provide for the outer layer to include nickel, iron and/or cobalt or an alloy comprising at least one of these materials. These materials have proven particularly hard and wear-resistant and have a very high strength. A further advantage of these materials is their good ability to bond to the copper material which may have been used for the inner layer.

[00021] A process solution is given by the features of claim 10.

[00022] This sequential process allows the at least two layers according to the invention to be bonded to the base material of the cylinder head in a particularly simple and reliable way, in terms of process engineering, while retaining the advantageous properties of the valve seat explained above.

[00023] A process which is particularly economical in terms of manufacturing technology results if the inner layer is placed onto the cylinder head in the form of a solid ring, and the outer layer is applied to the inner layer in powder form.

Brief Description of the Drawings

[00024] Further advantageous configurations and refinements of the invention will emerge from the remaining subclaims and from the exemplary embodiments outlined below with reference to the drawing, in which:

Fig. 1 shows a section through a valve seat according to the invention for a cylinder head of an internal combustion engine;

Fig. 2 shows an embodiment for carrying out the process according to the invention;

Fig. 3 shows a further embodiment for carrying out the process according to the invention; and

Fig. 4 shows a further embodiment of the process according to the invention.

Detailed Description of the Invention

[00025] Fig. 1 shows part of a cylinder head 1 of an internal combustion engine, which is not illustrated in its entirety. The cylinder head 1, in a manner which is known per se, has an intake port 2 which can be closed and opened by a gas exchange valve 3. When the gas exchange valve 3 is opened, a fuel/air mix can enter a combustion chamber 4 located beneath the cylinder head 1 from the intake port 2 in a manner which is

known per se. Furthermore, the cylinder head 1 has a valve seat 5, against which the gas exchange valve 3 bears in its closed position, in this way separating the intake port 2 from the combustion chamber 4.

[00026] As can also be seen from Fig. 1, the valve seat 5 has two layers 6 and 7 formed from respective additional materials, namely a lower or inner layer 6, facing the cylinder head 1, and an upper or outer layer 7, which is remote from the cylinder head 1 and faces the gas exchange valve 3. The inner layer 6 is used to join the valve seat 5 to the cylinder head 1 and therefore has good joining properties with respect to the base material of the cylinder head 1. The outer layer 7, by contrast, has good strength and wear properties in order to be able to absorb the forces acting on the valve seat 5 from the gas exchange valve 3.

[00027] Since in the present case the cylinder head 1 consists of a light metal, in particular of aluminum, copper or a copper alloy is used for the inner layer 6, since this material has a particularly good affinity for aluminum. In this case, in particular when using the alloy $CuAl_{10}$, i.e. a copper alloy containing 10 percent by weight of aluminum, the inner layer 6 is securely bonded to the material of the cylinder head 1. Moreover, iron has also proven to be a suitable further alloying constituent for the inner layer. However, it is also possible for pure copper to be used for the inner layer 6.

[00028] In addition to the good joining properties with respect to the base material of the cylinder head 1, the inner layer 6 also has good heat conduction properties in order to improve the dissipation of heat from the surface of the valve seat 5

into the cylinder head 1. This is because the air gap between the valve seat 5 and the cylinder head 1 is avoided by the melt-metallurgy bonding. In this context, the thermal conductivity of copper at 20°C is approx. 350 - 400 W/m·K, that of aluminum at 20°C is approx. 200 - 250 W/m·K and that of the alloy used for the inner layer 6 at 20°C is approx. 200 - 400 W/m·K.

[00029] To achieve the required strength, wear or hardness properties of the outer layer 7, it is preferable for nickel, iron and/or cobalt or an alloy comprising at least one of the materials to be used for this outer layer. Although a material of this type would tend to form intermetallic phases under certain circumstances when joined to the aluminum of the cylinder head 1, which could lead to the formation of cracks, the presence of the inner layer 6 means that the outer layer 7 is not joined to the cylinder head 1, and consequently intermetallic phases of this type do not arise.

[00030] In particular, chromium, silicon and molybdenum have proven particularly suitable as further alloying constituents for the material of the outer layer 7. A few alloys which can be used for the outer layer 7 are listed below by way of example; in addition to the three elements mentioned above, it is also possible for other elements to be used as further alloying constituents: Co25Cr10Ni7W0.5C, Co28Mo8Cr2Si, Co28Mo17Cr3Si, Ni17Cr6Al0.5Y, Ni22Cr10Al1.0Y, Ni25Cr6Al0.4Y, Ni31Cr11Al0.6Y, Ni23Co20Cr8.5Al4Ta0.6Y, Ni15Cr4Si3FeB0.75C, Ni21.5Cr8.5Mo3Fe0.5Co, Ni19Cr18Fe3Mo1Co1Ti or Ni8.5Cr7Al5Mo2Si2B2Fe3TiO2. Of course, this list makes no pretence to be complete, and it is possible to employ materials used in commercially available valve seat rings. The choice of

materials also depends, inter alia, on whether the cylinder head 1 is used in a spark-ignition or diesel internal combustion engine.

[00031] If other materials are used for the cylinder head 1, it is, of course, also possible for the two layers 6 and 7 to consist of other materials which ensure that the inner layer 6 has good bonding properties with respect to the base material of the cylinder head 1 and the outer layer 7 has good strength and wear properties.

[00032] Fig. 2 and Fig. 3 show two different processes used to produce the valve seat 5 by fusing the additional materials mentioned above to the cylinder head 1; only the application of the inner layer 6 to the cylinder head 1 is illustrated.

[00033] In the embodiment shown in Fig. 2, a nozzle 8 which discharges the additional material for forming the inner layer 6 toward the cylinder head 1 is arranged in the region of the valve seat 5 that is to be formed. As soon as the additional material comes into contact with the cylinder head 1 or enters a groove formed therein, it is simultaneously fused to the outer layer of the base material of the cylinder head 1 by a laser beam 9, in order to produce a molten material 10 at the cylinder head 1. During production of the groove, the machining operation is matched to the coating process. As an alternative to the laser beam 9 described, it is also possible for an electron beam (not shown) or a suitable device for producing the molten material 10 from the additional material 7 by the application or introduction of energy, to be used as the energy source. The additional material 7 is in this case applied in powder form; it can also be applied in the form of a strip.

[00034] To achieve a continuous process, the nozzle 8 and the laser beam 9 are advanced continuously along a circular path corresponding to the contour of the valve seat 5. When the laser beam 9 has moved away from the molten material 10, in the direction of advance corresponding to arrow A, the molten material solidifies to form the inner layer 6. This is what is known as a single-stage process.

[00035] Fig. 3 shows an alternative process for producing the valve seat 5, in which the additional material is placed into a groove in the cylinder head 1 or placed onto the cylinder head 1, for example in the form of a paste, a wire, a sintered body or a powder preform, preferably in the shape of a ring, and is then fused to form the molten material 10 by the laser beam 9 or an electron beam. In this case, too, the inner layer 6 of the valve seat 5 is formed from the molten material 10 after the removal of the laser beam 9 in arrow direction A. This process is known as a two-stage process.

[00036] The outer layer 7 can be applied in a very similar way in both processes, although it is, of course, being fused not to the cylinder head 1, but rather to the inner layer 6. A combination of these two processes, in which, for example, the inner layer 6 can be placed onto the cylinder head 1 in the form of a ring and then the outer layer 7 can be joined to the inner layer 6 in powder form, is also possible.

[00037] Fig. 4 provides a highly diagrammatic representation of a further possible way of carrying out the process for producing the valve seat 5. In this case, there are two laser or electron beams 9 and 9′, of which the first laser beam 9 is

responsible for joining the inner layer 6 to the cylinder head 1, and the second laser beam 9' is responsible for joining the outer layer 7 to the inner layer 6. Since the molten material 10 of the inner layer 6 has solidified as soon as the laser beam 9 has moved just a few millimeters away in the direction of arrow A, the second laser beam 9' can track the first laser beam 9 at a relatively short distance, so that the entire process for producing the valve seat 5 takes up only slightly more time than if the valve seat 5 were to consist of just one layer. This process can be carried out in an advantageous way if the outer layer 7 is applied in powder form, it being possible for the material for the inner layer 6 to be applied in a manner as described above.